SCIENCE

NEW SERIES
VOL. LV, No. 1411

FRIDAY, JANUARY 13, 1922

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $6.00

SCIENCE

A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

11 Liberty St., Utica, N. Y. Garrison, N. Y.

New York City: Grand Central Terminal

Single Copies, 15 Cts. Annual Subscription, $6.00

Application made for transfer of entry to Utica, N. Y., as second-class matter.

VOL. LV JANUARY 13, 1922 No. 1411

OBSERVATION VERSUS EXPERIMENTATION[1]

IN gatherings of scientific men such as this one, it is customary to have a number of non-technical addresses, which often take the form of general surveys of certain fields of science, with summaries of what is known in various directions, and with indications of problems which await solution. The topic which I have chosen, however, would indicate that for the moment it seems to me worth while to stop and discuss somewhat the methods of science rather than the results. No doubt all of us look upon both observation and experimentation as necessary evils, the means to arrive at ends or results which are much more important and attractive in themselves than are the processes of obtaining them.

Before a company of astronomers the contest between observation and experimentation might be anticipated to mean a discussion of the relative merits of the old and new astronomy, the astronomy of position, or of precision as its devotees often call it, and the newer field of astrophysics. Or the contest might be between the whole field of astronomy on the one side and the domain of physics and other experimental sciences on the other, for we astronomers have the reputation of being precise and painstaking observers, while the experimenters have, to our minds at least, the habit of spending most of their energies in getting ready to be precise, and then when they are prepared to take what we would call observations, their aim is achieved and they pass on to something else. But my purpose is rather to consider somewhat the struggle which often goes on in the mind of the investigator himself, whether he shall after a certain amount of

[1] Address of the retiring vice-president and chairman of Section D—Astronomy, American Association for the Advancement of Science, Toronto, December, 1921.

preparation begin observing, or whether he shall consider that his conditions are not yet favorable for exact work. Likewise the question may come up in any long series of observations: When is it better to stop and try to improve things rather than to go on in a routine? A similar choice may come to an individual even in deciding his preference for one science or another, and in the fundamental sense this same choice runs through much of our lives, the attraction of the old versus the new.

While we may take up certain considerations from the limited point of view of astronomers, there are undoubtedly applications of these same ideas in many fields of science. Of course we are all interested in improvements, and no one of us would care to admit that he has not the patience and concentration to keep at a task until he has mastered it and can do it well. There are, however, differences in individuals, and as time goes on these are accentuated, and each worker naturally tends to gravitate into the field where he works best and feels at home. The skillful observer is usually an orderly person who keeps his surroundings and apparatus neat and tidy. His instinct is to maintain constant conditions, and if his instrument or apparatus is working perfectly, to let everything remains undisturbed. There is good reason for this, since experience often shows that variation of conditions introduces unsuspected errors. The experimenter, on the other hand, seems to take delight in being surrounded by the débris of his work. Order and system are not part of his creed. He has no hesitancy in dissecting any fine new instrument if some of its pieces will fit in with what he wants, probably much to the consternation of his colleague who is responsible for the equipment. Whenever the observer sees or does anything, he writes down a note, but writing is the last thing of which the experimenter thinks. The observer takes apparatus as it comes to him, the experimenter improves apparatus or devises something new. The observer keeps all or almost all his work, the experimenter has no scruples in throwing away anything which he thinks he can improve upon.

I remember visiting a laboratory in company with a prominent astronomer, where we were shown some spectrum photographs. The physicist in charge showed us a negative which he had just taken, and then threw it aside. My companion promptly asked if there could not be something of value on that plate, if it should not be kept. The experimenter answered that he had dozens equally poor, and that he could reproduce it at will. To the observer even a poor photograph may represent an opportunity which will never return.

It is much easier to teach large classes of students to observe, after a fashion, than to experiment. In a laboratory section, the student will consider favorably a system which enables him to come in and sit down at his table, and without delay to begin and simply take readings. We hear a great deal about teaching the scientific method, but it would be quite impracticable to inflict upon elementary students the real methods of science, the trials and waste of time which any one must undergo before he can determine what he needs, and then find and assemble his apparatus.

There is one direction in which an observer sometimes feels that he has the advantage over the experimenter, and that is in this matter of waste of time. An hour's work for the observer brings an hour's results, whereas the experimenter often puts in a great deal of effort with apparently no return. A safe program of observation brings in sure returns; but is not any one mistaken in assuming that he can avoid waste of effort? It is the fate of most scientific work to be superseded, and the most accurate observations are likely to be quite out of date even in the lifetime of an individual. Bradley's star places have been and are still of great importance as a basis for proper motions of stars, but the time will come when the so-called modern observations will be of the same order of antiquity as those of a century and a half ago, and Bradley's observations will gradually lose their importance. On the other hand, there are many results from positions and proper motions of stars determined from current measures which are obviously of permanent value. Such a case is Boss's cluster in Taurus, a group of stars now widely dispersed, but which as time goes on

will gradually condense and become more and more conspicuous as an illustration of what can be predicted from precise data.

Photographic parallax determinations seem to be relegating all previous results to the discard, but parallax observers might as well hurry and get these results while they are still valuable, as the spectroscopic method though at present dependent upon the trigonometric results for a basis need not always remain so, and the mere possibility of interferometer measures of parallaxes should be enough to dampen one's enthusiasm for undertaking too large a program of safe and sane trigonometric determinations.

One of the striking differences between observers and experimenters is their use of the method of least squares. I have heard a young physicist state that he had been advised against taking a course in least squares, because he would never have occasion to use that subject in physics. The answer is that both he and his adviser have probably used the method a great deal, without being aware of it. Experimenters as a rule do not repeat measures enough to get many residuals—one astronomer has said that he wants at least fifty observations to determine a reliable probable error—but the method of least squares is by no means as limited in its usefulness as might be imagined. It is striking in how many fields of exact science the discussion of measurements takes the directions of a graphical exhibition of the results. The experimenter gets some measures which he puts on a graph exhibiting, say, the dependence of one variable upon another. Through a series of plotted points he proceeds to draw a curve; but how does he draw this curve Just what does he try to do when he makes a smooth line pass through a series of points Even for the simplest case of a straight line if you ask a student what he does, he may say that he tries to draw the line as "near as possible to all of the points," whatever they may mean, or he may try to have as many points on one side as on the other side of the line. It is very doubtful if by intuition he will draw that line which makes the sum of the squares of the residuals a minimum, and it is difficult to see how he is to fit any curve to observations without using some of the principles of the method of least squares.

In passing it might be noted that some authors still persist in publishing curves without representing the observed points on which these curves are based. Such a suppression of evidence should not be countenanced. especially as the graph of the original observations gives any one else such a convenience test of the reliability of the curves.

An application of the method of least squares which is of the utmost importance to the experimenter is in the law of propagation of error. The well known relation

$$R^2 = \left(\frac{dX}{dx_1}\right)^2 r_1^2 + \left(\frac{dX}{dx_2}\right)^2 r_2^2 + \cdots$$

where R is the probable error of X, a function of several measured quantities, X_1, X_2, ..., is not only useful for determining the probable error of a result, but is even more important in planning a program of observation or of experimentation. Where several quantities enter into a determination there is no object in spending time or effort in the wrong place, and one wonders at the tremendous amount of misdirected effort which is constantly being wasted because of investigators measuring and being careful about the wrong thing, when an elementary acquaintance with this formula would show them which of the various sources of error was contributing most to the inaccuracy of the result. Another advantage of the method of least squares is that it enables a number of unknown quantities to be disentangled from a mass of data where it has been impossible for the experimenter to differentiate with respect to one variable at a time. In astronomical practice this is too elementary even to mention, but it is amazing how physicists and others can get along without knowing how to proceed when the conditions are such that they can make only indirect observations on several quantities. It is, of course, the safest practice to measure directly the quantity sought, and to vary but one thing at a time when that is possible, but an experimenter may find advantage in knowing how to derive several unknowns simultaneously.

However, with all of the advantages of the method of least squares, it is not so seldom

that its devotees may go too far with it. How often it occurs that the accuracy of a series of measures as indicated by the probable error is illusory In almost every field of exact measurement we have the presence of both accidental and systematic errors, and he is an optimist indeed who deals with only the former. It is here that the experimenter is at an advantage, as he naturally is constantly seeking to eliminate undesirable factors, and by constantly changing conditions may vary or eliminate what may be called the systematic errors.

It has been said that a worker in exact science usually goes through three stages of attitude toward his work. He starts out by considering every small or unexpected discrepancy as due to a physical reality; after being deceived a sufficient number of times, he has a reaction, and nothing is proved until it is really proved; he then gradually grows back into a state where he is neither too exultant at the first prospect of a discovery, nor too pessimistic over the insufficiency of the evidence for a result which he hopes to establish. We may quote from Langley, who in the discussion of small irregularities of his bolometer records of the solar spectrum said, "When we approach the limits of vision or audition, or of perception by any other of the human senses, no matter how these may be fortified by instrumental aid, we finally perceive, and always must perceive a condition, a condition still beyond, where certitude becomes incertitude, although we may not be able to designate precisely where one ceases and the other begins. This is always the case, it would seem, on the boundaries of our knowledge in every department, and it is so here."

In the estimate of the precision of a given result there is not yet adherence to the logical use of the probable error as a measure of precision or accordance; astronomers long ago adopted this usage, but others seem to get along without it. Only recently I heard in a public address the statement that a certain measure could be made "with an error of one part in a thousand." Just what was meant by this would be difficult to determine, especially as the speaker afterwards said that the "range did not exceed one part in a thousand." These loose statements did not come from a beginner but from a master in the art of exact measurement. Still another example is found in a recent number of a standard journal: "The maximum error is .1 per cent." This is presumably some sort of estimate of the possible systematic error of the result, but one would think that physicists would come to some common ground in describing their errors, so that they could understand each other. One suspects that here we have simply an illustration of the difference between the observer and the experimenter; the former stays with his measures long enough to have a real basis for computing a probable error, the latter has a few measures, and even if he used the formula for the probable error he would be doubtful of its value. Experimenters boast when they have achieved "astronomical precision" in the number of significant figures in their results, but they might equally well cultivate some astronomical accuracy of statement when it comes to describing the reliability or accordance of their results.

The term "astronomical" precision brings to mind the prediction of some years ago that most new discoveries in physics would be in the sixth place of decimals. Whatever else may be said concerning the advances in that science, it will not be maintained that so many significant figures have been necessary to establish the important results. Intelligent lay opinion might be somewhat shocked to learn by what methods astronomers are measuring or estimating distances of stars. A mere guess at the mass of a stellar system may give its distance with far greater accuracy than could possibly be secured by the method of exact measurement. The new things in science continue to be not in the last place but often in the first place of decimals. We should be quite happy to have one significant figure correct in a measure of the size of the visible universe.

There is one particular field in astronomy where the technique of observing as at present practiced is a constant reminder to the observer that either he or some one else had better do some experimenting, and that is in astronomical photography. Many an observer during the tedious hours of long exposure

must have felt that some of his time might better be devoted to increasing the sensitivity of the photographic plate, rather than to be continuing the drudgery of keeping a telescope accurately on a star for hours at a time. However, the astronomer knows well that the plate makers themselves are fully alive to the desirability of faster plates, which would have such an enormous commercial value that the astronomical applications would seem trivial in comparison. Nevertheless, one can not but speculate on the field which would be opened to small telescopes if the photographic plate were increased say tenfold in sensitivity, not to mention the power which would then come to large instruments.

There is little need of discussing the relative advantages of large and small telescopes, one might as well discuss the possibilities of abundant and meager resources; but there is at least the consolation to a possessor of a small instrument that he does not need to use it all the time simply to justify the capital expenditure in his equipment. He is therefore much freer to try out new ideas, and even to waste a great deal of time, without the immediate necessity of producing results in proportion to his facilities. The large and well equipped institutions have by no means a monopoly on revolutionary improvements or discoveries.

The choice of an individual between joining a large or a small institution may or may not be the same as the choice between observation and experimentation. In some large places he may become simply a cog in the machine, and easily sink into a narrow routine. On the other hand, the resources of a large place may make it possible for him to try out various schemes which would be quite impossible if he were off by himself. On the whole, one must balance the advantages of each type of institution, but he is a fortunate individual if he has free choice in which direction he will work. There is one resource, however, which is necessary to all scientific investigation, and this is the item of time. You may deprive the investigator of much of his physical equipment and resources, and with plenty of free time he can go on, almost with bare hands as it were; but take away the opportunity to make continued effort, and he will cease to produce. As an illustration of what may be done with almost no equipment we may cite the case of the late Simon Newcomb, who while visiting at a summer resort made a determination of the fundamental quantity, the total light of all the stars. His apparatus comprised only several spectacle lenses, but he succeeded in obtaining a result, and any possessor of a large telescope would be satisfied if he could with all his means occasionally produce something as valuable as that work of Professor Newcomb.

But after all, both the experimenter and observer need to discuss their work, and this entails a certain amount of computation. As a rule the observer becomes more adept in the art of computation simply because he has more of it to do, but either observer or experimenter will probably look upon long computations simply as necessary evils. It has been said of a certain astronomer that his dream of heaven is a sky full of comets and a room full of computers to work out their orbits for him. This reminds us that most important of all is theorization; all of the routine of scientific work, experimentation, observation, and computation are simply a means to an end. The real joy consists in sitting at one's desk and making discoveries which come out of previous work, either from one's own or from that of others. Perhaps the ideal case is where a single individual is able to partake in all phases of investigation, from the preliminary securing of data up to the final discussion of the theoretical bearing of the results. In the old days this was more easy to do than now, for as science becomes more and more complex it is increasingly difficult for one person to master the technique of all the processes involved in a single problem, and with the growth of cooperative research it is possible for several workers to join hands and accomplish what would be far beyond the powers of any one of them. But in any cooperative scheme it should be borne in mind that what is wanted is real cooperation on a democratic basis, and not a direction of individuals by a so-called master mind. Efficient as an autocratic system may be, in science as in other fields it ultimately

fails in the question of morale, for when young scientific workers see that however attractive may be the places of the men at the top, the chances for any individual are that he will become only a part of an efficient machine, then a man of ambition will choose some machine where the material rewards are greater than in science.

One great disadvantage in the arrangement of separating the observer and the computer is that a realization of attainable accuracy is likely to be lost. It sometimes seems that the farther the computer is removed in time and place from the original observations, the greater is the accuracy which these observations take on. A good illustration is in some modern computations of results based upon old observations of variable stars. The method of Argelander, of simply looking first at one star and then at another, and estimating the difference of brightness, is still of the utmost value, but errors as great as ten or twenty per cent, in the ratio of the light of two stars are not uncommon. We can make the accuracy seem greater by expressing the estimate in stellar magnitude, when the errors are only one or two tenths of a magnitude, but the fact remains that the discordances are a large fraction of the quantities sought. Some computers taking results of such estimates have managed to derive elements of variable stars where some of the derived quantities are expressed to five significant figures, although the original data were often wrong in the second figure. This fictitious accuracy seems to come from a state of mind where the more you compute the more figures you get, and the investigator needs the restraining influence of experience in securing observational data. Of course, the computer, if he goes about it in the right way, can really show the observer just how accurate the measures are, but in his anxiety to establish some fine theory the computer sometimes loses his own sense of proportion.

And so it goes; the observer does not know how to observe unless he realizes the value of experiment; the experimenter loses a great deal if he has not acquired the technique of observation; neither the experimenter nor the observer can work to the best advantage unless he has the proper theoretical background; and the pure theorist may be saved from various grotesque mistakes if he becomes acquainted with some of the methods and difficulties of securing the facts of physical science.

We may, therefore, best dwell not on the differences among experimenters, observers, and theorists, but rather on their strength when united and working together. No matter how well rounded an individual may become, his capabilities may be easily surpassed by a group of cooperating workers. If it be objected that new ideas will not originate in a committee, the answer is that any one of us has plenty of ideas, many of them fundamental and important, but what we lack is the ability and power to put our ideas into execution. It is here that to my mind lies the great advantage of the policy of the National Research Council in bringing together in committee workers from all over the country so that they can form plans of joint attack on various problems. In our universities and other institutions there is great opportunity for cooperative effort between colleagues, but even in the same institution or department the interests may be so divergent that a worker may find little help of just the kind that he needs, whereas in some other parts of the country may be one or more competitors who, if they can be got together to talk things over, will turn out to be only hearty collaborators.

Astronomy is called the oldest of the sciences; our friends in other fields say that it has been in the lead in America, and especially that astronomers were the first to organize cooperation in research. Let us not fail to continue to deserve this good name, and to set the example in so far as we can of free trade and mutual good will in the solving of our problems.

Joel Stebbins
University of Illinois Observatory

GENERAL FEATURES OF THE TORONTO MEETING

The second Toronto meeting of the American Association for the Advancement of Science and of the associated scientific societies,

which was held during the last week of the year just ended, was the seventy-fourth meeting of the association. It was successful in every way and must go on record as the most satisfactory meeting thus far held, aside from the greater, four-yearly meetings. Some of these greater meetings—as the last Chicago meeting, for example—have surpassed it in the number of those in attendance, and in the number of societies meeting with the association, but it is safe to say that the second Toronto meeting was at least equal to any previous meeting in other respects. Fourteen sections of the association were represented, and twenty-six associated societies. The general program,[1] of 95 pages, showed the programs of all sections and societies. About nine hundred addresses and contributed papers were presented, representing nearly all branches of science. If these were printed together they would make four large volumes.

The total number of those in attendance was 1,832, geographically distributed as shown below:

SUMMARY:	
United States, including Hawaii and the Philippine Islands	867
Canada	953
England, Belgium and Japan	12
Total	1,832
BY REGIONS:	
City of Toronto	686
Ontario outside of Toronto	186
Quebec	34
New Brunswick, Nova Scotia and Prince Edward Island	15
New York State	199
Maine, Vermont, New Hampshire and Rhode Island	34
Massachusetts	48
Connecticut	19
Pennsylvania	68
New Jersey	28
District of Columbia	57
West Virginia, Virginia, Delaware and Maryland	39
Ohio	59
Michigan	48
Indiana, Kentucky and Tennessee	34
Wisconsin	30
Illinois	77
Minnesota, Iowa and Missouri	54
North Dakota, South Dakota, Nebraska and Kansas	19
Saskatchewan and Manitoba	22
Montana, Wyoming and Colorado	13
British Columbia and Alberta	10
Washington, Oregon, California, Idaho, Nevada and Utah	11
North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Arkansas	16
Arizona, New Mexico, Texas and Oklahoma	12
England	5
Belgium	3
Hawaii	1
Philippine Islands	1
Japan	4

On the afternoon of Monday, December 26, the day before the official opening, the secretaries of the sections met with the general secretary and the permanent secretary to discuss some of the general problems of the association. They dined together and continued their conference in the evening. On Tuesday afternoon Dr. F. R. Moulton, professor of astronomy in the University of Chicago, showed some very fine motion pictures on scientific subjects, illustrating the use of motion pictures in education. The films were furnished by the Society for Visual Education of Chicago.

This meeting of the association and the associated societies was held in Toronto on invitation of the University of Toronto and of the Royal Canadian Institute. The sessions were held in the buildings of the university, which are excellently adapted for such purposes, while the majority of those in attendance were very conveniently housed in the university dormitories. Meals were served in the university dining halls. These arrangements proved to be unusually convenient and satisfactory for all, and especially for those

[1] Fifteen hundred copies of the general program were printed, but this number proved to be inadequate, and many of those who registered late in the meeting did not receive copies. A few copies are now available in the permanent secretary's Washington office, and these may be had by members on request, as long as the supply lasts.

who roomed at the university. For these there was comparatively little need for going back and forth between the university grounds and the down-town section of the city. The hospitality of the University of Toronto and of the Toronto friends of science was greatly appreciated.

The meeting was formally opened on the evening of Tuesday, December 27, in Convocation Hall, the University of Toronto, under the able presidency of Dr. E. H. Moore, professor of mathematics in the University of Chicago, who was introduced by the retiring president, Dr. L. O. Howard, chief of the Bureau of Entomology of the U. S. Department of Agriculture, who was permanent secretary of the association for many years. Sir Robert Falconer, president of the university, delivered an admirable address of welcome, calling attention especially to the close and friendly relations that have so long obtained between Canada and the United States. This was followed by the address of the retiring president. Among many other interesting things, Dr. Howard called attention to the fact that the average age of the presidents of the British and of the American Association since 1895 is about the same—61 years and 11 months for the British and 61 years and 5 months for the American. The second part of Dr. Howard's address dealt with the topic, The War against the Insects. He considered the unceasing warfare that must be waged by mankind against the almost countless and omnipresent forms of insect life which threaten the very existence of the human race. Dr. Howard's address has been printed in full in SCIENCE, for December 30, 1921. The opening sessions were followed by a reception in the room behind Convocation Hall, where members and their friends had opportunity to meet one another and to examine the exhibits of scientific apparatus and products brought together under the auspices of the association for this meeting.

On Wednesday afternoon many members of the association and their friends visited the Royal Ontario Museum, on special invitation, and enjoyed the opportunity of seeing the exceptionally fine collections of the museum.

The Wednesday evening session, in Convocation Hall, was of a twofold character. Professor William Bateson, director of the John Innes Horticultural Institution, Merton Park, Surrey, England, who was present at Toronto by joint invitation of the American Association and the American Society of Zoologists, delivered a stimulating address on "Evolutionary Faith and Modern Doubts." He clearly emphasized the point that students of evolution harbor no doubts as to the *fact* of evolution, but the exact *mode* of evolution remains still an unsolved problem. Professor Bateson's address will be printed in SCIENCE.

At the close of this address the session was transformed into a convocation of the University of Toronto, Sir Robert Falconer presiding, at which the degree of Doctor of Science *honoris causa* was conferred on Professor Bateson, Retiring President Howard and President Moore. A reception followed the convocation.

Sir Adam Beck, chairman of the Hydro-Electric Commission of Ontario, addressed a general session, on Thursday afternoon, under the auspices of Section M (Engineering). His subject was "Hydro-Electric Developments in Ontario." After pointing out how these developments have been due to the men of pure science, as well as to those of applied science—the electric and the hydraulic engineers—Sir Adam traced briefly the history of the hydro-electric enterprises of Ontario, showing how the commission is able to deliver electric power from Niagara Falls in Windsor (254 miles away) at a price only about one third as great as that of steam-generated electricity in Detroit, across the river. Electricity for the common home is supplied at minimum cost. Sir Adam showed a series of moving pictures, illustrating the various hydro-electric projects in Ontario.

The Thursday evening conversazione in Hart House was one of the greatest social functions ever held in Toronto and was unique in the history of the association. For three hours the two thousand guests of the university and the Royal Canadian Institute enjoyed the entertainment facilities of the magnificent students' social center in Queen's Park. The

theater beneath the quadrangle of the big building was filled three times during the evening; Mr. J. Campbell McInnis rendered three very fine song programs, Irish, Scotch and English. The string quartette in the music room was a center of attraction. The band of the 48th Highlanders played near the Great Hall, and the pipers promenaded the corridors. An exhibition in the sketch room attracted those interested in art and architecture. Many athletic features were enjoyed, including water polo in the natatorium, indoor base-ball, basket ball, squash in the squash courts, boxing, wrestling and fencing. Supper was served in the Great Hall, in the dining hall of the Faculty Union and in the Graduate Commons. The conversazione will be long remembered by all who were present; it not only furnished entertainment and a very pleasant social evening, but it also provided opportunity to renew friendships and to form new ones and to exchange views regarding the work and plans of those in attendance.

To give visitors a sample of Canadian winter sports, "A Half Hour with the Toronto Skating Club" was provided on Friday afternoon, in the Arena, with artificial ice. An exhibition of artistic figure-skating was followed by a hockey match between the Varsity Intermediates and the St. Helen's Intermediates.

A most interesting showing of scientific apparatus and products was open throughout the meeting, in the room behind Convocation Hall. The arrangements for this exhibition were in charge of the Subcommittee on Exhibits, of which Professor E. F. Burton was chairman, and the work of the subcommittee was greatly appreciated. A British firm exhibited various articles of fused silica ("vitreosil"), exceedingly resistant to acids and alkalis and capable of withstanding very high temperatures and rapid temperature changes. Dr. MacKenzie's ink polygraph, which makes simultaneous tracings of the beats of the pulse, heart and jugular vein, was among the instruments shown. There was an interesting exhibit of the action of Stoechel's tube. A collection of books showing the extension courses given by the University of Toronto, and another on the question of an international auxiliary language were interesting parts of the exhibition.

A collection of Canadian paintings was on exhibition during the meeting, under the auspices of the Royal Canadian Academy, in the Art Gallery of Toronto. A collection of fine water-color paintings of mountain and glacier subjects, the work of Professor A. P. Coleman, formed a part of the exhibition in the Convocation Hall building; also an extraordinary collection of artistic photographs, exhibited by the Toronto Camera Club.

A women's reception room was maintained throughout the meeting, in the library building, and tea was served here every afternoon.

The Toronto meeting was especially international in character. It emphasized the point that the American Association is an international organization. Although the majority of its members are residents of the United States, it was clearly visualized at Toronto how much the future of the association depends upon Canadians. The meeting was an occasion for a pronounced increase in the Canadian membership, and it is hoped that the time will soon come when Canadian scientists will all regard the association as theirs. A wonderfully fine spirit of international good-fellowship and understanding prevailed throughout the second Toronto meeting and hovered benignly over the multitudinous and varied sessions.

The weather throughout the meeting was fine indeed—cold enough to be stimulating and with almost unclouded sky. The use of artificial ice for winter sports in Toronto furnished an agreeable surprise to those who had anticipated arctic cold.

Many well-attended dinners were held during the meeting, by the various groups of scientists. A list of these follows: (1) For mathematicians, physicists and astronomers; (2) for geologists and engineers; (3) for zoologists; (4) for entomologists; (5) for naturalists; (6) for ecologists; (7) for botanists; (8) for phytopathologists; (9) for psychologists; (10) for agriculturists; (11) for foresters; (12) the annual metric dinner; (13) the Sigma Xi dinner; (14) the Gamma Alpha dinner; (15) the Phi Kappa Phi dinner. Besides these, there was the biological smoker. An important feature of the meeting was the

Women's Dinner, held in the Great Hall of Hart House on Friday evening. Those attending dinners held in the university buildings on Friday evening enjoyed several entertaining surprise features introduced by the Local Committee, including selections by the bagpipers and the choristers, and several other musical numbers. At most of the dinners toasts were proposed and responded to, with many inspiring after-dinner speeches.

The programs of the sections and of the societies associated with them were generally extensive, and all were interesting and important. The vice-presidential and presidential addresses will be noted in a later issue of SCIENCE, as will also the various symposia of these programs. Special mention should be made here of the program of Section M (Engineering) (which presented no program at the recent Chicago meeting), and of the symposium on "An International Auxiliary Language," which was arranged for Toronto under the auspices of Section K (Social and Economic Sciences).

The Engineering program was unusually excellent in many ways. Arrangements for this were due to the very efficient work of Mr. J. B. Tyrrell, of Toronto, vice-president of Section M. The Society for the Promotion of Engineering Education met with the section. The engineering program began on Tuesday forenoon, with an address on the "Natural Resources of Canada" by the Honorable Sir Clifford Sifton, K.C.M.G., etc., formerly minister of the interior, and head of the Conservation Commission of the Dominion of Canada. The program continued through Thursday afternoon, with two sessions each day, many of the papers being illustrated by motion pictures. It was concluded by Sir Adam Beck's address on "Hydro-Electric Developments in Ontario," given at the Thursday afternoon general session of the association as a whole, the engineering section furnishing this important feature of the general sessions. The two engineering sessions on Friday were under the auspices of the Society for the Promotion of Engineering Education. A very enjoyable dinner of engineers and geologists was held in the Music Room of Hart House on Friday evening, at which a number of inspiring speakers were heard. The president of the university and the general secretary and the permanent secretary of the association were among the guests.

The social and economic sciences (Section K) had no separate program at the Toronto meeting, but a new symposium topic of very broad interest was introduced under the auspices of this section. Through the enthusiastic and efficient work of Dr. F. G. Cottrell, of the U. S. National Research Council, this symposium was arranged, on "An International Auxiliary Language." It was held at a joint session on Friday afternoon, of Sections K and Q (Education). The symposium was preceded by the delivery of the address of the retiring vice-president of Section K, Dr. Frederick L. Hoffman, of the Prudential Life Insurance Company of America, on "The Organization of Knowledge." Dr. Hoffman emphasized the imperative need for better methods in the classification of knowledge, so that what science has already accomplished may become much more easily available. He presented an improved scheme of classification that promises to be very valuable in this important and fundamental field of scientific endeavor. Related to Section K was the program of the American Metric Association, which held two sessions on Thursday and a dinner on Thursday evening, with papers and addresses favoring the more general use of the metric system of weights and measures.

A program of great general and cultural interest was presented by the Committee on the History of Science, in a session held on Thursday forenoon. Among others, Dr. J. Playfair McMurrich—afterwards elected president of the association for 1922—gave a paper on the artistic-anatomical work of Leonardo da Vinci.

Chemical science (Section C) was unusually well represented at the Toronto meeting. Section C took part in four joint sessions with other sections and associated societies, including the Canadian Institute of Chemistry and the Toronto Section of the Society of Chemical Industry. A symposium on the Quantum Theory and a joint session with the Physio-

logical Section of the Botanical Society of America were of special importance.

Section N (Medical Sciences) presented a symposium on "The Health and Development of the Child." The successful efforts of Dr. A. J. Goldfarb, of the College of the City of New York, secretary of Section N for the Toronto meeting, in arranging this program were greatly appreciated.

The extraordinary success of the meeting was due mainly to the tireless and varied activities of the members of the Local Committee for the second Toronto meeting, who foresaw all needed arrangements and added many pleasant and convenient extras. Most of the general arrangements were practically complete at the time of the general and permanent secretaries' preliminary visit to Toronto (November 21-23), and the three following weeks were occupied in working out the manifold details. The permanent secretary wishes to emphasize the efficient and cordial spirit of cooperation and help with which the members of the Local Committee responded to all requests and inquiries from Washington during the somewhat hectic weeks just before the meeting.

The Local Committee consisted of the following members: J. C. Fields, *Chairman;* F. A. Mouré, *Hon.-Treasurer;* H. L. Seymour, *Secretary;* the Honorable Henry Cockshutt, Lieutenant-Governor of Ontario; J. W. Bain; E. W. Banting; S. G. Bennett; E. A. Bott; G. S. Brett; E. F. Burton; J. R. Cockburn; the Honorable Manning Doherty; D. A. Dunlap; Sir Robert Falconer, President of the University of Toronto; Lady Falconer; Sir Joseph Flavelle; A. E. Gooderham; the Honorable R. H. Grant; A. Hunter; A. G. Huntsman; H. V. F. Jones; A. D. LePan; J. J. MacKenzie; J. C. McLennan; J. P. McMurrich; W. L. Miller; C. H. Mitchell; J. M. D. Olmsted; Sir Edmund Osler; I. R. Pounder; Sir Clifford Sifton; Sir Edmund Walker; C. H. C. Wright. The Local Subcommittees, with their respective chairmen, were as follows: Hospitality, Sir Robert Falconer; Entertainment and Dinners, I. R. Pounder; Ladies, Lady Falconer; The Hart House Conversazione, S. G. Bennett; Dormitories, J. M. D. Olmsted; Hotels, G. S. Brett; Transportation and Reception, C. H. C. Wright; Meeting Places, E. A. Bott; Exhibits, E. F. Burton; Signs and Messenger Service, E. W. Banting; General Program and Other Printing, J. P. McMurrich; Publicity, A. G. Huntsman; Membership, H. V. F. Jones; Registration Room, J. R. Cockburn.

Dr. Fields and Mr. Seymour are to be thanked for their indefatigable attention to all details, which made the meeting so exceptional. Especially was the very artistic official badge praised. It is a metal button with a narrow raised margin and the design in relief. The design consists of the figure of a beaver with a wreath of maple leaves, and the words "Toronto, A. A. A. S., 1921." This badge will serve as a worthy commemoration of one of the most satisfactory meetings of the association.

All those present keenly appreciated the kindness, efficiency and facility with which Sir Robert Falconer and Lady Falconer represented the University of Toronto, and they received the thanks of all for their personal hospitality as well as for that of the university. Visitors could not avoid noticing how much the university staff had put themselves out (frequently in the literal as well as in the figurative sense) so that the rooms might be available for the scientific sessions, and so forth. It is no inconsiderable inconvenience to a university staff to have their rooms occupied by others during practically the whole of the holiday vacation, and the hearty thanks of the association are due to the members of the University of Toronto.

As chairman of the subcommittee on Exhibits, Professor E. F. Burton did a great service to the association and to the cause of science; so satisfactory was the Toronto exhibition that it is hoped an exhibition of scientific apparatus may become a regular part of the annual meetings.

The very onerous and pressing work of caring for the publication of the general program was done by Dr. J. P. McMurrich, who handled this very difficult and confusing complex of details with great skill. It should be noted that the entire program—a book of 95

pages—had to be printed in a single week from the time the first batches of manuscript were received by Dr. McMurrich. Indeed, most of the program manuscripts did not reach him till December 20 and 21, and the book was completed by noon on December 24. The University of Toronto Press gave very efficient and really wonderful service in this connection.

The registration room, in charge of the executive assistant, Mr. Sam Woodley, was conveniently and centrally located, in the library building of the university. An able corps of assistants was provided, and the work of the registration office went forward with exceptional smoothness. The same form of visible directory as was used at the last annual meeting was employed at Toronto, and this again proved to be a valuable feature of the meeting. By this plan, a continuously corrected list of those in attendance, with their home addresses and those for the meeting, is kept convenient for public consultation in the registration room. The assistant secretary, Dr. Sam F. Trelease, assisted the permanent secretary in many ways, aside from his work as secretary of the council. He gave valuable service in the editing of the manuscripts for the general program before they were sent to Toronto be printed. He has also helped very much in the preparation of the present paper and the other reports of the meeting that are to be published in SCIENCE.

Publicity was unusually well handled at the Toronto meeting. As was announced in the preliminary announcement and also in SCIENCE before the meeting, the recently organized Science Service cooperated with the association in arousing public interest in the meeting, through the daily press. Dr. E. E. Slosson, editor of Science Service, and Mr. Watson Davis were present throughout the meeting, on behalf of the Science Service. Many of the papers occurring on the programs at Toronto were given attention in the weekly "Science News Bulletin" sent to newspapers by the Science Service for the week of the meeting, and many dailies received each day from the service a 500-word telegraphic report on the meeting.

Besides the valuable publicity work of the Science Service, which is under the control of the American Association, the U. S. National Academy and the U. S. National Research Council, and which operates for the sole purpose of disseminating scientific knowledge through the newspapers, just as valuable and efficient publicity work was accomplished by the Local Subcommittee on Publicity, of which Professor A. G. Huntsman was chairman. At Professor Huntsman's suggestion, a new feature was introduced this year by the permanent secretary's office. As the manuscripts for the general program came in during the week preceding Christmas day, the names of all speakers were copied off, after which the manuscripts were edited and forwarded to Toronto for printing. To each name occurring on each day's list was addressed a letter asking for an abstract of the paper to be given at Toronto by that individual, and enclosing a blank form for this abstract, to be returned to Professor Huntsman. This work had to be done with great rapidity, but large numbers of abstracts were received and these furnished material for the work of the Subcommittee on Publicity. It seems desirable to develop this feature of special personal requests for abstracts and to retain it for future annual meetings of the association. Professor Huntsman and his colleagues used the abstracts as they came in, so as to have representative and suitable material ready for the newspapers during the meeting, and they thus secured for the association unusually excellent and exceptionally satisfactory treatment by the daily press of Toronto and other cities.

A report of the proceedings of the Council at Toronto will appear in a later issue of SCIENCE.

BURTON E. LIVINGSTON,
Permanent Secretary.

CAROLINE BURLING THOMPSON
1869-1921

DR. CAROLINE BURLING THOMPSON, professor of zoology at Wellesley College, died on December 5, 1921. Professor Thompson was noted not only for the excellence and thoroughness of her original methods of teaching, but also

for her original research work in biology. She was an inspiration to her students and also found means of helping them in many practical ways, unknown to any but herself.

Miss Thompson did original research work in biology in connection with the marine laboratories both at Naples, Italy, and Woods Hole, Mass. Her most noted work was on the biology of termites—the most destructive of the social insects. She has been a collaborator of the Branch of Forest Entomology, Bureau of Entomology, U. S. Department of Agriculture, since March, 1917.

1916 saw Miss Thompson's first paper on termites. It was an original piece of research on the brain and frontal gland of a common termite of eastern United States. She discovered that there was very little differentiation between the brains of the different castes of this termite and none between the sexes, the most marked difference being in the optic apparatus. Miss Thompson suggests that the frontal gland may have arisen phylogenetically from the ancestral median ocellus now lacking. This work was of considerable importance, since the frontal gland is of great taxonomic value.

In 1917, a paper on the origin of the castes of a common termite revolutionized the attitude taken by students of termites. Hitherto the attitude had been almost entirely anthropocentric; Dr. Thompson disproved that the "complementary" or "substitute" queens or reproductive forms of termites could be manufactured through feeding by workers. She definitely proved that the origin of all castes is due to intrinsic causes. Thus, by careful scientific study, much of the mystery of the "complex" social system of the termites—which has led to admiration by man of these insects—has been proved a myth. Facts now supplant the older fantastic theories, so dear to writers of the eighteenth and nineteenth centuries.

Another paper in 1919 discussed the phylogeny of the termite castes and outlined breeding experiments which were in progress at the time of her death. It was hoped to work out a genetic formula for termites.

These papers were followed by several others on the development of the castes and reproductive forms of species of many genera of termites.

Work on the development of the castes of the honey bee had been planned and material fixed ready to section. It is to be regretted that ill health and other duties interfered. Miss Thompson was undertaking this work as she ever did with an open mind—realizing that very careful work had been done on the honey bee and that no generalizations could be made in advance. The social insects often radically differ in habits. What might be an anthropocentrism in case of the termites, might be a fact in the biology of the honey bee!

With two other co-workers, Miss Thompson was working on a more or less popular book on termites and her share was to be the internal anatomy of termites as well as phylogeny and genetic work.

A kindly, helpful spirit, of keen mind, but modest—Miss Thompson will be long remembered by her students and co-workers in science. A striking point in Dr. Thompson's personality, in fact its key note and which signalized her as an investigator and as a teacher, is that with all her splendid training and her admirable technique she was not biased by the current fashions of the school in which she was trained, but struck out into new fields. Her own research work will endure forever!

T. E. S.

WASHINGTON, D. C.
DECEMBER 10, 1921.

SCIENTIFIC EVENTS

THE HECKSCHER RESEARCH FOUNDATION

THE following grants have been made during the year 1921 by the Heckscher Research Foundation for the support of investigation at Cornell University:

1. To Professor J. Q. Adams a sum sufficient to secure his release from the duties of teaching for the first term of the year 1921-1922, to enable him to complete his book on "The Life of Shakespeare."

2. $2,000 to Professor C. C. Bidwell to enable him to carry on cryogenic measurements, and to study the relation between electrical conductivity and temperature for so-called "variable" conductors.

3. $700 to Professor J. C. Bradley to cover the cost of preparing illustrations and otherwise completing a manuscript embodying the results of investigations of the wing venation of Hymenoptera.

4. $1,200 to Professor A. W. Browne to aid him in investigations of certain problems in the field of the oxidation of hydrazine, especially in non-aqueous solutions (grant increased to $1,800).

5. $350 to Professor L. M. Dennis for carrying on investigations on the "Separation of the Isotopes of Lead by Chemical Processes."

5. $2,000 to Professor L. M. Dennis in aid of investigation of the preparation and properties of germanium and its compounds.

7. $500 to Professor F. L. Fairbanks for the purpose of developing and completing a traction dynamometer.

8. $250 to Professor S. H. Gage and Professor P. A. Fish for colored plates needed in completing the manuscript of an investigation concerning the digestion and assimulation of fat in the human and animal body.

9. $200 to Professor V. Karapetoff for an assistant and materials in carrying on investigations on mechanical aids in the design of electrical machinery and lines.

10. $1,125 to Professor W. R. Orndorff and Professor R. C. Gibbs to enable them to carry on more rapidly their investigations of the absorption spectra of certain organic compounds.

11. $1,800 to Professor F. K. Richtmyer for investigations in the laws of the absorption of X-rays.

12. To Professor E. W. Schoder a sum sufficient to secure his release from the duties of teaching for the first term of the year 1921-1922, in order that he may prepare for publication results of investigations in hydraulics, made by himself and the late Professor Turner.

13. $100 to Professor Sutherland Simpson to enable him to continue his investigations into the functions of the thyroid and parathyroid glands.

14. $500 to Professor A. H. Wright for investigation of the life history of North American frogs, toads and tree toads. Grant later increased by $350.

15. $1,200 to Professor V. Snyder to secure his release from the duties of teaching during the second term of 1921-1922, in order to permit him to continue during that term his studies of algebraic correspondences.

16. $1,400 to Professors W. R. Orndorff and R. C. Gibbs for the purchase of apparatus to be used in connection with investigations of absorption spectra of certain organic compounds.

17. $500 to Professor C. C. Bidwell for the purchase of metals to carry on cryogenic measurements.

18. $1,000 to Professor F. K. Richtmyer for apparatus to be used in research on the absorption of X-rays by various media.

19. $1,800 to Professor Wallace Notestein for editing historical documents on the parliamentary history of England.

20. $500 to Mr. H. S. Vandiver for investigations on the subject of algebraic numbers.

21. $500 to Professor J. G. Needham and Dr. P. W. Claassen for preparing a monograph on the Plecoptera of North America.

22. $750 to Professor B. F. Kingsbury for use in studies of the early developmental pattern.

23. $500 to Professor H. Hermannsson for use in the study of Icelandic books of the seventeenth century.

24. $850 to Professor H. M. Fitzpatrick for aid in the study of a large group of fungi known as the Pyrenomycetes.

25. $150 to Professor A. A. Allen to assist in experiments in the artificial propagation of the ruffed grouse and the canvasback duck.

26. $600 to Professor W. C. Ballard for use in an investigation into high power electron tubes.

28. $900 to Mr. H. S. Vandiver for use in continuing his investigations on algebraic numbers.

Supplement to No. 17. $500 to Professor C. C. Bidwell to continue his work on the chemical purification of metals.

29. $500 to Professor R. M. Ogden for use in completing a monograph on the psychology of audition.

30. $800 to Professor E. M. Chamot to cover the cost of publication of the "Results of Microscopic Investigations of Small Arms Primers."

31. $500 to Professor A. H. Wright for the publication of "A Biological Reconnaissance of Okefinokee Swamp."

32. $1,000 to Professor F. C. Prescott for the publication of a book entitled "The Poetic Mind."

33. $2,500 to Professor Clark S. Northrup for the publication of a book entitled "A Register of Bibliographies of the English Language and Literatures."

34. $500 to Professor R. H. Keniston and Professor G. H. Hamilton for the publication of a critical and linguistic study of an old Spanish poem, "El Libro de los Tres Reyes de Oriente."

35. $300 to Professor G. G. Bogert for research into the law of conditional sales.

36. $2,000 to Professor V. Karapetoff for investigations on mechanical aids in the design of electrical machinery and lines, and a study of fields of force or flow, electric, magnetic and hydraulic.

Supplement to No. 19. $150 to Professor Wallace Notestein to continue his work of editing historical documents.

37. $1,500 to Professors Bancroft, Chamot and Merritt for the study of structural colors in feathers.

Supplement to No. 25. $150 to Professor A. A. Allen to enable him to continue his experiments in the artificial propagation of the ruffed grouse and the canvasback duck.

38. $450 to Professors Orndorff and Gibbs for a study of the absorption spectra of orthocresolsulphonphthalein and other related compounds.

39. $3,000 to Professor J. S. Shearer for the study of the selective absorption of X-rays, and of new methods of exciting X-ray tubes.

Supplement to No. 3. $450 to Professor J. C. Bradley to enable him to complete his illustrations of the wing venation of Hymenoptera.

Supplement to No. 11. An additional sum of $450 to Professor F. K. Richtmyer for further investigations in the laws of the absorption of X-rays.

40. $3,000 to Professor H. Diederichs for study of the infiltration of air into buildings through walls and windows, the development of a satisfactory heat treatment of "Kinite" alloy steel, and of the combustion process in a Diesel engine.

41. $700 to Professor C. R. Crosby for drawings of the genitalia of a group of spiders, the linyphiidæ, to be used in devising a natural system of classification of the species and to determine the limits of the general and their affinities.

42. $300 to Professor W. F. Willcox for statistical investigations.

43. $300 to Professor W. L. Westermann for editing Greek papyri owned by Cornell University.

THE STANDARDIZATION OF BIOLOGICAL STAINS

THE need of standardizing stains for biological uses has become increasingly evident during the last four or five years. During this period German stains have been either difficult to obtain or entirely unavailable; and the American products, although often excellent, have varied so much one from another as to give uncertain results. The manufacturers have been willing to meet the demand of biologists, but the latter have generally been uncertain just what they wanted. The efforts of the Society of American Bacteriologists to clarify the situation have already been mentioned in this publication[1]. More recently other societies have offered to assist in the work, many of the men concerned expressing a wish not to try to duplicate the Grubler stains, but to secure domestic stains better than their foreign predecessors.

The interest thus awakened led to a conference held on November 5, 1921, at the Chemists Club, New York City, to discuss the standardization of biological stains and the steps to be taken to develop a reliable American supply. The conference was under the auspices of the National Research Council, Dr. L. R. Jones, chairman of the Division of Biology and Agriculture, presiding. Those present were: L. R. Jones, H. E. Howe, and C. E. McClung, of the Research Council (Dr. McClung also representing the American Society of Zoologists); E. D. Ball and J. A. Ambler, of the Department of Agriculture; W. F. Keohan, of the Chemical Foundation; R. A. Harper and T. E. Hazen, representing the Botanical Society of America; H. J. Conn, representing the Society of American Bacteriologists; and R. T. Will of the Will Corporation.

H. J. Conn spoke for the Bacteriological Society, stating the interests of this society in the matter and showing what had been accomplished during the past year by cooperative work among the members of the society. He stated that stains must be standardized by three different methods: by chemical analysis, by testing for bacterial staining, and by testing for histological purposes. So far as bacterial staining is concerned, he considered his society to be already in a position to select satisfactory samples of basic fuchsin and methylene blue, and believed that the work now in progress on gentian violet would soon lead to a similar result in regard to that stain.

[1] H. J. Conn. The Production of Biological Stains in America. SCI. N. S., 53, 289-290.

The chemical and the histological work still remained to be done.

J. A. Ambler, of the Color Laboratory of the Department of Agriculture, with the approval of Dr. Ball, offered the resources of this laboratory to help in the work and undertake to make chemical analyses of samples that had already been tested by the Society of American Bacteriologists.

Drs. McClung, Harper and Hazen stated that some of the samples which were very satisfactory to bacteriologists did not give good results in cytological or histological staining, and agreed that considerable work was necessary to standardize the stains for this purpose. They offered to take steps to secure the active interest of their respective societies in this. It was pointed out that the zoologists had already appointed Dr. S. I. Kornhauser to assist in the work and that Dr. Victor C. Vaughan as chairman of the Division of Medicine had given assurance of the interest and support of that profession. Drs. Harper and McClung were appointed to act as a temporary committee with Dr. H. J. Conn on the organization of further plans including the nomination of a standing committee to the National Research Council. Such a committee has since been authorized to function under the Division of Biology and Agriculture, with the Division of Medicine cooperating, the membership of which is: H. J. Conn, Geneva, N. Y. (Chairman); S. I. Kornhauser, Denison University; L. W. Sharp, Cornell University; Frederick G. Novy, University of Michigan; F. B. Mallory, Boston City Hospital. The Chemical Foundation of New York City has agreed to support the undertaking, and has already deposited with the treasurer of the National Research Council $500.

INTERNATIONALIZING SERA STANDARDS

Cooperation of the foremost laboratories of the world, including the United States, for the unification of international standards of anti-toxic sera has been begun on a large scale by the League of Nations Health Committee. Two preparatory conferences have been held; the work has been divided amongst the various national laboratories, and the individual studies have been begun.

The United States has agreed to cooperate through the United States Public Health Service at Washington, and through the presence at the conference of Dr. Rupert Blue, assistant surgeon general, stationed at Paris. German scientific men, as well as Japanese, and representatives of all the greater European medical services will take part.

Up to the present there has been much confusion in the various national standards of measuring the strength of anti-toxic sera for diseases such as dysentery, tetanus, diphtheria, syphilis, etc. This has had two serious effects. Men of science have been handicapped in studying methods of treatment of various vital diseases abroad, because of the different standards of measuring the strength of the anti-toxic sera employed; secondly, as international trade in sera is increasing, it represents not only an inconvenience, but a positive danger to have their strengths listed at varying standards.

In order to obviate these difficulties, the Health Committee of the League of Nations began a series of studies last October, which resulted in an international conference at London in December, to prepare plans for the first joint experimental inquiry of the sort ever attempted. A program was adopted whereby the study of the effects of the various standards was divided according to diseases amongst the various laboratories represented. To the Hygienic Laboratory at Washington it was proposed to allocate the study of tetanus and diphtheria. As soon as these studies have been completed, they will be coordinated through the State Serum Institute at Copenhagen.

Other bodies which will cooperate in the work are the Medical Research Council of Great Britain, The Pasteur Institute of France, the State Institute of Italy, State Institute of Warsaw, Hygienic Institute of Basle, Pasteur Institute of Brussels, Kitasato Institute of Japan, as well as Austrian and German organizations.

RELIEF WORK OF BRITISH UNIVEPSITIES

Maurice de Bunsen, chairman of the universities' committee, writes in *Nature* concern-

ing the activities of the Imperial War Relief Fund, Universities' Committee. This committee, which was created at an inter-university conference which met at University College, London, on July 7, 1920, at the invitation of Lord Robert Cecil, and under the auspices of the Imperial War Relief Fund, has set before it the aim of presenting to the British universities the appeal of the universities in the war-stricken areas of Europe. Mr. de Bunsen writes:

During the first year of the existence of the Universities' Committee 32,000*l*. was raised in cooperation with every university in Great Britain and Ireland. The committee at the opening of this university year carefully considered the problem of the Central European universities at the present time, and decided that it would be absolutely necessary for us to maintain the relief work promoted by the committee in cooperation with universities all over the world throughout the coming year.

I may say briefly that the financial panic which has swept through Austria in particular during the last month has threatened the very existence of many distinguished men in universities of that country.

The Universities' Committee has also taken on the further responsibility of endeavoring to raise funds for the relief of men of learning and students in Russia. In careful consultation with Dr. Nansen, the committee is establishing those links in Russia which shall ensure a wise distribution of the funds subscribed. Dr. Nansen has issued a personal appeal to the universities of the world to help to save from extinction the rapidly diminishing numbers of men in Russia who have been able to go through the ordeal of suffering to which many of them have been subjected during the past few years.

In a letter to graduate members of the British universities on behalf of the men of learning of Austria an urgent appeal has been made over the following signatures of distinguished representatives of learning: William Bragg, Bryce, A. S. Eddington, Richard Gregory, Haldane of Cloan, Frederic G. Kenyon, Walter Lock, Donald Macalister, Charles J. Martin, Henry A. Miers, Gilbert Murray, E. Rutherford, M. E. Sadler, Arthur Schuster, Napier Shaw, A. E. Shipley, George Adam Smith, Ernest H. Starling, J. J. Thomson.

THE SOUTHWESTERN DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE second annual meeting will be held in Tucson, Arizona, from January 26 to 28. The University of Arizona has kindly offered the use of its buildings during this period. There will be four sections with chairmen as follows: Biological, Dr. Charles T. Vorhies, professor of biology of the University of Arizona; Physical science, Dr. V. M. Slipher, director of the Lowell Observatory of Flagstaff, Arizona; Social science, Dr. Edgar L. Hewett, director of the Archælogical museums at Sante Fe, N. M.; and the section on Education and Psychology, chairman to be selected.

The presidential address of Dr. A. E. Douglass will be delivered on the evening of the 26th., to be followed by a reception. On the evening of the 27th. the program will be under the auspices of the Arizona Archælogical Society. There will be illustrated lectures on the recent archælogical researches made in the Southwest. On the evening of the 28th. there will be a characteristic dance by the Yaqui Indians from Sonora.

There will be exhibits of southwestern animals, insects, plants and minerals. The new Stewart Observatory will be demonstrated under the direction of Dr. Douglass. The observatory is complete except for the 36-inch reflecting lens, the first casting of which failed owing to an electrical storm.

ELLIOTT C. PRENTISS,
Chairman of the Executive Committee.

SCIENTIFIC NOTES AND NEWS

AT the meetings held at Amherst, Dr. W. D. Mathews, of the American Museum of Natural History, was elected president of the American Paleontological Society, Dr. Waldemar Lindgren of the Massachusetts Institute of Technology president of the Society of Economic Geologists and Professor T. L. Walker of the University of Toronto president of the Mineralogical Society.

AT the recent meeting of the American Psychological Association at Princeton, Professor Knight Dunlap, of the Johns Hopkins

University, was elected president. Two new members of the council were elected: Professor Warner Brown, of the University of California, and Dr. F. L. Wells, of the Psychopathic Hospital, Boston.

Dr. W. C. Farabee, curator of the Museum of the University of Pennsylvania, was elected president of the American Anthropological Association at the Brooklyn meeting.

The Perkin medal of the American Section of the Society of Chemical Industry, was presented on January 13, to William M. Burton, chemist of the Standard Oil Company of Indiana. Presentation addresses were made by Sumner R. Church, R. F. Ruttan, Charles H. Herty, Russell Wiles and Charles F. Chandler, to which Mr. Burton replied.

Dr. E. P. Hyde, director of the Nela Research Laboratories, was made president of the International Commission on Illumination which met lately in Paris.

Dr. A. W. Rogers has been elected president of the South African Association for the Advancement of Science to preside at the next annual meeting to be held in July at Lourenco Marques.

We learn from *Nature* that Professor Horace Lamb, Sir Ernest Rutherford, Sir Arthur Schuster and Professor G. Elliot Smith have been elected honorary members of the Manchester Literary and Philosophical Society.

The honorary degree of doctor of science has been conferred by the University of Calcutta on Sir W. J. Pope, professor of chemistry, Cambridge University, and on Professor C. V. Raman, professor of physics, University of Calcutta.

Among the prizes recently awarded by the Paris Academy of Sciences was one to E. Roubaud for his works on malaria in France and the disappearance of malaria in temperate climates.

The *British Medical Journal* reports that the eminent histological anatomist Professor Johan August Hammar, of Upsala, celebrated his sixtieth birthday on August 21, and received on this occasion from his fellows, friends and pupils a *Festskrift* containing thirty-eight scientific papers written in Swedish, German, and English, covering over a thousand pages.

The position of naturalist of the *Albatross* in the Bureau of Fisheries, which for some time has been vacant for lack of an available candidate of suitable qualifications, has been filled by the appointment of Paul S. Galtsoff, who was formerly chief zoologist of the Russian Academy of Sciences and assistant director of the marine biological station at Sebastopol.

Earle E. Richardson, instructor in analytical chemistry and physics for the past four years at the Massachusetts Institute of Technology, has been appointed research physicist at the Eastman Kodak Company, Rochester, N. Y.

J. E. Walters, F. W. Schroeder and Frank Porter, chemists at the helium plant of the Bureau of Mines at Petrolia, Texas, have been transferred to the new cryogenic laboratory of the Bureau in Washington, D. C.

Dr. Ralph W. G. Wyckoff, of the Geophysical Laboratory, Carnegie Institution of Washington, is on a year's leave of absence, which he will spend at the California Institute of Technology at Pasadena, California.

The third Asiatic Expedition of the American Museum, under the leadership of Mr. Roy Chapman Andrews, is beginning its work in China, with the cooperation of Dr. Yen, minister of foreign affairs, and other members of the cabinet in Pekin. Dr. V. K. Ting, director of the National Geological Survey of China, and Dr. J. G. Anderson, mining adviser to the Chinese Government and curator of the Museum of the Geological Survey of China, have also given assistance.

Dr. Samuel J. Mixter, of Boston, delivered the Hodgen Lecture, under the auspices of the St. Louis Surgical Society and the Medical Fund Society on January 4.

William A. Durgin has been given leave of absence from the Commonwealth Edison Company, Chicago, to direct the new activities

of the Department of Commerce toward the elimination of waste in industry by simplifying and standardizing commercial practices. The new organization will form a subdivision of the Bureau of Standards.

THE Huxley lecture at the University of Birmingham was delivered on November 25 by Professor C. Lloyd Morgan on "A philosophy of evolution."

CHARLES DARWIN'S birthplace, according to the London *Times,* has been sold. The purchase includes the Darwin Walk above the Severn River. It is said that its future use is to be for the Office of Works to house a body of clerks.

DR. HUBERT WORK, president of the American Medical Association, has appointed as the Commitee on the Gorgas Memorial, Drs. George E. de Schweinitz, Philadelphia; Charles W. Richardson, Washington, D. C., and Fred B. Lund, Boston. This appointment was made in compliance with the request received by the Board of Trustees from the Gorgas Memorial Institute of Tropical and Preventive Medicine of Panama for the cooperation of the American Medical Association.

DR. HOWARD B. CROSS of the Rockefeller Institute for Medical Research died at Vera Cruz on December 27 from yellow fever contracted at Tuxtepec. Dr. Cross was a member of the staff of the International Health Board of the Rockefeller Foundation. He was a graduate of the University of Oklahoma and received the doctorate of philosophy from the Johns Hopkins University in 1921.

THE death is announced at the age of 57 years of Max Verworn, professor of physiology at the University of Bonn.

DR. G. P. JORDAN, port health officer of Hong-Kong and professor of tropical medicine in the Hong-Kong University, died in London on December 4 at the age of 64 years.

THE spring meeting of the American Electrochemical Society is to be held in Baltimore from April 27 to 29. There will be three sessions, dealing respectively with electric furnace cast iron, the electrochemical industries and electromotive chemistry. Inspection trips will be made through industrial plants near Baltimore.

THE Association of German Men of Science and Physicians will hold its centennial meeting in Leipzig from September 17 to 23.

AT the recent meeting of the American Psychological Association in Princeton, N. J., provision was made for the accrediting as consulting psychologists of qualified persons belonging to the American Psychological Association. The committee asks that members of the Section for Clinical Psychology of this association desiring such action on their behalf await the receipt of a circular letter of instructions as to their procedure. Other members of the association are asked to await a further announcement of the committee which will be forwarded to SCIENCE and to the *Psychological Bulletin.*

THE annual report shows that the work of the United States Geological Survey for last year included detailed geologic surveys of 4,600 square miles, reconnaissance geologic surveys of 21,500 square miles, exploratory geologic surveys of 18,000 square miles, cooperative geologic work with 17 state organizations, studies of ore deposits in 10 states, oil and gas surveys in 10 states, geologic surveys in Alaska of 1,500 square miles, and the continuation of studies of mineral deposits in Alaska. It included also topographic surveys in the United States of 12,311 square miles and topographic reconnaissance surveys in the Alaska Range of 390 square miles, running of 4,796 miles of levels, establishing 1,123 bench marks and making 576 linear miles of river surveys. The Geological Survey continued measurements of stream flow throughout the United States and in Alaska and Hawaii, cooperating in part with other federal organizations and with 31 states and Hawaii; also continued investigation of waterpower resources of Southeastern Alaska. It also made field examinations in 11 states under the enlarged homestead and stock-raising homestead laws, increased designations of stock-raising lands by 31,000,000 acres, and reported

on 7,000 applications for oil and gas prospecting permits, on 249 applications for coal prospecting permits, on 78 applications for coal leases and 7,500 applications under the mineral-leasing laws. It also conducted an engineering investigation and prepared an exhaustive report on a proposed "superpower system"—a comprehensive system for the generation and distribution of electricity for the operation of railroads and manufacturing industries in the region between Boston and Washington. Special publications of the year were "Guides to desert watering places in Arizona and California," and a large relief map of the United States. Other published reports numbered 132, containing more than 10,000 pages, and 60 new topographic maps were engraved and printed. The Survey distributed 631,000 books and 740,000 maps, of which latter 550,000 were sold.

UNIVERSITY AND EDUCATIONAL NOTES

A movement has been started to raise a fund of $2,000,000 to establish a medical school as a memorial to Major General William C. Gorgas. The present plan is that the fund be contributed by the nation and that the school be situated in Tuscaloosa, Ala., where General Gorgas lived as a boy. Dr. Seale Harris, of Birmingham, Ala., is chairman of the national committee.

Fire of unknown origin has almost completely destroyed the chemical building of the Colorado State Agricultural College at Fort Collins, Colo. The loss on buildings and equipment is estimated at $70,000.

The board of curators of the University of Missouri has elected Dr. John Carleton Jones, president of the university to succeed Dr. A. Ross Hill who resigned several months ago to become connected with the American Red Cross. Dr. Jones has been vice president of the university since 1918 and dean of the college of arts and sciences.

John H. Moffett has been appointed associate professor of metallurgy in the University of Minnesota.

R. S. Lowe, of the nitrate division, Ordnance Department, U. S. A., has been appointed dean of the department of chemical engineering, University of Cincinnati.

Reverend Dr. Charles Wesley Flint, president of Cornell College at Mount Vernon, Iowa, has been elected chancellor of Syracuse University in succession to Dr. James Roscoe Day.

Dr. Walter F. Tittman, formerly of the Bureau of Mines and later engaged in consulting practice at Pittsburgh, Pa., has been appointed head of the department of commercial engineering, Carnegie Institution of Technology.

Dr. Harold Diehl has been appointed head of the health service of the University of Minnesota, Minneapolis, to succeed Dr. John Sundwall.

DISCUSSION AND CORRESPONDENCE

COMMITTEE FOR THE PROTECTION OF ANIMAL EXPERIMENTATION

Some weeks ago it suddenly became apparent that the activities of the various antivivisection societies had finally reached a strength where they were able to menace effectively the health of the community. On a referendum vote in California they threatened all animal experimentation last year, and it was only with some difficulty that the measure was defeated. The Interstate Convention of Antivivisection Societies was held in Boston last month and at that time a committee was organized to undertake a campaign of sane, humane education to combat the propaganda of those who seek to prevent the making of vaccines and antitoxins, the testing of all such drugs as ergot and a general interference with medical methods of proved efficacy for the diagnosis, the prevention and cure of disease.

A committee of the Boston Society of Natural History was first appointed of which T. Barbour was chairman, to arrange for Mr. Ernest Harold Baynes to deliver two lectures, one upon a "Nature Study" subject, the other

entitled "The Truth about Vivisection." Mr. Baynes delivered the last lecture December 17 to a large and enthusiastic audience in Huntington Hall, Boston. It was an amplification of the article which he prepared for the *Woman's Home Companion,* July, 1921, and which at once aroused a howl of consternation from all of the antivivisection groups in the country. So much interest was aroused in the general question that the lecture committee of the Boston Society of Natural History reorganized itself into the Committee for the Protection of Animal Experimentation. An appeal for funds, signed by President Charles W. Eliot, Professor Richard P. Strong, M. D., Ernest Harold Baynes, Dr. John C. Phillips, Dr. Edward Wigglesworth, Dr. Townsend W. Thorndike and Dr. Thomas Barbour, brought a most encouraging response. The committee has published several statements, designed to instruct the community as to just what the results may be if the antivivisectionists succeed.

Cardinal O'Connell was one of the first to endorse the movement in a most inspiring letter which was followed by letters of endorsement from persons in all stations of life and representing many different interests, particularly Life Insurance Companies, Agricultural Interests and Charitable Organizations of many sorts.

The newspapers gave the work of the committee generous publicity and its efforts as a whole have become so successful that there is now a widely expressed desire that the work of the committee be carried forward by some permanent organization. The committee has studied carefully the organization and work of the Research Defense Society in England and it is probable that some organization of this sort will be founded.

To be really effective the Society should be national in its scope and have an able, active field secretary and should aim to protect the public from the mischievous activities, not only of the antivivisectionists, but the antivaccinationists, the medical freedomists, so-called, and all others who aim to lower the standards of medical education or jeopardize the public health in other ways.

A correspondence is invited with those interested and our literature is available for free distribution.

EDWARD WIGGLESWORTH, PH. D.
J. C. PHILLIPS, M. D.
T. BARBOUR, PH. D.
FOR THE COMMITTEE

POISONOUS SPIDERS

One of the best reviews of our knowledge of the poisonous properties of spiders is contained in Dr. Henry C. McCook's beautifully illustrated volumes, "American spiders and their spinning work." In Volume 1, page 274, he concludes that most of the cases of serious poison in the United States are caused by the bite of the widely distributed Lineweaver, *Lactrodectus mactans,* and the Saltigrade, *Phidippus morsitans.* He cites an instance of serious sickness resulting from the bite on a man's back of *Lactrodectus.* He also thinks it very probable that the large Mygales, commonly called tarantulas, on account of their large fangs and exceptionally large supply of poison, can inflict very serious bites.

He cites instances of spiders killing fish and birds, in one instance the victims being two sunfish about two inches long, which were promptly killed by the poison of a spider I saw at work. From my description Dr. McCook thought this was a Dolomedes.

In his third volume Dr. McCook quotes Professor Bentkau of Bonn, who suffered very serious pain and general swelling from being twice bitten by a *Chiraianthium nutrix* on the fingers.

Dr. McCook thinks it most likely that even the bites of the first two mentioned species are in most instances of small consequence and that the bites of the great majority of spiders are of little more consequence than those of mosquitoes and not nearly as serious as the stings of bees, hornets, etc.

In instances that have come under my direct observation of spiders biting human beings the results have been comparable with mosquito bites.

F. R. WELSH

A LONG-LIVED WOODBORER

IN SCIENCE, Friday, August 5, 1921, H. E. Jaques, Iowa Wesleyan College, Mt. Pleasant, Iowa, contributed a note, "A Long-lived Wood-

borer." It was intimated that *eburia quadrigeminata* (Say) spent forty years growing from egg to mature larva, in the top piece of an old birch bookcase. A number of such stories are current, but I am of the opinion that the simple solution of the whole matter is as follows: *Eburia quadrigeminata* breeds in the heartwood of dead, dry, seasoned logs and wood,—*Hicoria, Quercus, Robinia, Betula, Fagus, Fraxinus, Castanea, Ulmus* and perhaps others. The eggs are placed in the cracks and crevices of dry, weathered or seasoned scars, "cat faces," and similar placed. An impregnated female in some manner got into the house, and in crawling over the piece of furniture took advantage of a crack in the varnish or wood, and inserted an egg.

I can not believe that any Cerambycid larva could exist for forty years in a piece of furniture. In fact, the normal duration of the larval stage of insects of this family is from one to five years.

I think the same explanation will cover the other case mentioned in this article. The adults of this species often hide beneath bark, and might have crawled between the bricks and doorsill.

A. B. CHAMPLAIN

PENNSYLVANIA BUREAU
OF PLANT INDUSTRY,
HARRISBURG, PA.

PERCIVAL LOWELL

THE absorbing interest that Dr. Percival Lowell was able to throw about the astronomical investigations of his later years has obscured to an extent the fact that he was a man of many parts. There are comparatively few who are familiar with his keen observations of the nearer Orient, crystallized into published essays, and fewer still have known of his interest in botany, geology and general natural history, in one or more departments of which he has made contributions to science.

A comprehensive view of him is presented in Miss Louise Leonard's recent volume, "Percival Lowell—An Afterglow" (Boston: The Gorham Press), a book which through the medium of selections from his own writings shows him in his variety of studies. No serious undertaking has yet been made towards a biography of Lowell—the time since he passed on is perhaps yet too short, but in this volume one has a valuable reminder of him. Extracts from his letters are deftly framed in a Foreword, a prelude and an afterpiece, the last a poem that he loved. There is no appraisal of Dr. Lowell's scientific achievements, but everywhere is reflected his spirit of investigation, cheerfulness and wish to help his fellow man.

J. R.

THE PASTEUR CENTENARY

THE year 1922 marks the lapse of a century from the year of Louis Pasteur's birth and a "Centenary" volume of Pasteur's collected scientific writings would be a fitting homage to the memory of such a man.

In view of the conditions in Europe, is it not possible for investigators here to sponsor such an undertaking, in the English language, and contribute to it by means of translations of the original French articles and memoirs?

AUGUSTO BONAZZI

OHIO AGRICULTURAL
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WOOSTER, OHIO

SCIENTIFIC BOOKS

Insect Transformation. By GEORGE H. CARPENTER, D. Sc., Professor of Zoology, Royal College of Science, Dublin, London. Methuen & Co. Ltd. 1921, pp. 282, figs. 124.

PROFESSOR CARPENTER for many years has been doing admirable work in Ireland. Well trained in biology, and a broad zoologist, he has interested himself in many aspects of scientific work. His publications on crop and animal pests have been of great service to the Irish farmers and stock growers; he has been much interested in the admirable zoological garden in Dublin, where they breed lions in confinement more successfully than in any other place in the world, and has been active in the Royal Irish Academy, of which he is secretary.

His book on "Insect Transformation," just published, is a mature book, written by a broad man, and differs in many interesting and important ways from any book yet published.

It bears on every page evidence of competent knowledge, very broad reading and deep reflection.

There are only seven chapters in the book of nearly three hundred pages. The first one is devoted to "Form, Growth and Change," beginning with an examination of the structure, both external and internal, of the adult insect. His second chapter is entitled "The Open Type of Wing Growth," using this term to characterize those insects which have incomplete metamorphosis. The next chapter is devoted to "The Hidden Type of Wing Growth," in which he makes a careful and full exposition of the structure in different stages of those insects which have complete metamorphosis and therefore in which the wing growth is hidden in the larval form. Another chapter treats of "Some Wingless Insects." Then comes a fascinating and very full chapter, covering nearly sixty pages, on "Growing Insects and Their Surroundings," a condensed insect ecology of great value and admirably done.

The last chapter is devoted to "The Problems of Transformation," in which he contrasts the transformations of insects and the changes which other animals undergo in the course of their development, considering the primitive type of insect larva, the two types of wing growth, and the history of the insect orders as revealed by the rocks.

In the earlier chapters it will be seen that the author gives an account of the growth and transformation of the insects of the different orders, showing especially the astounding variations among the early stages, particularly the larvae. The excellent and extensive ecological chapter "On the Surroundings of Growing Insects" follows most naturally; while in the final chapter, with equal happiness of arrangement, he really considers the meaning of the facts described in the earlier pages.

Prepared in this way and by a thoroughly competent man, this attractive, well printed, and very well illustrated book will find its readers not only among the entomologists but among those interested in biology in a broad way.

L. O. HOWARD

RESEARCH FUNDS IN THE UNITED STATES

IN the Bulletin of the National Research Council for March, 1921, Callie Hull has compiled information on the funds available in the United States in 1920 for scientific research. This is the first compilation of its kind, and readers of SCIENCE will be interested in seeing a brief summary of the contents of this paper. The following review of these statistics can not be considered absolutely accurate. In some cases it is difficult to judge of the application of some arbitrary rules that had to be adopted in order to make the tables brief. I am satisfied, however, that the tables are essentially reliable, and that if absolutely correct figures could be obtained in every case, no great variation from the figures here given would result.

Annual incomes from funds for scientific research in the United States, which have been set aside by private individuals or corporations, range in amounts from less than $25.00 to more than $10,000,000. It is interesting to note the distribution over our land of the institutions that dispense these funds. Most of them are on the Atlantic coast, from Connecticut to South Carolina. The principal centers are Boston, New York and Washington. There is a broad belt of smaller centers extending from the Atlantic westward through the northern states to beyond the Mississippi. On the Pacific coast we find a center in and around San Francisco. Very few research funds have been established in the states lying on the high plains and plateaus of the west, where culture is recent, or in the southern states, where there is as yet relatively little centralization of wealth.

Funds of this kind have been established only in 26 states. Of these, New York ranks first and North Dakota last. In the amount of established funds the rank of these states is as follows: (1) New York, (2) Massachusetts, (3) Illinois, (4) California, (5) Maryland, (6) Pennsylvania, (7) Minnesota, (8) New Jersey, (9) Iowa, (10) Connecticut, (11) Ohio, (12) Kansas, (13) Utah, (14) Wisconsin, (15) Indiana, (16) Michigan, (17) Missouri, (18) Alabama, (19) Washington, (20) Texas, (21) Rhode Island, (22) Idaho, (23)

		Number of funds
Yielding income annually of	more than $1,000,000	3
Yielding income annually of	$1,000,000–$100,001	7
Yielding income annually of	$100,000–$10,001	67
Yielding income annually of	$10,000–$1,001	150
Yielding income annually of	$1,000–$101	298
Yielding income annually of	$100 or less	40*
		565

* Many of the smaller funds in the last two items are research scholarships in various universities.

Virginia, (24) North Carolina, (25) Arizona, (26) North Dakota. The District of Columbia ranks next to New York.

There are in all some 565 funds available for research in our country, and these may be classified according to size, as in the above table:

The donations made for such funds have greatly increased during the last twenty years, as will be seen from the following table:

Period covered	No. of new funds established in each period	Annual yield
Up to 1800	3	$ 1,000
1800 to 1850	3	$ 50,000
1851 to 1870	4	$ 5,000
1871 to 1880	5	$ 60,000
1881 to 1890	17	$ 40,000
1891 to 1900	44	$ 166,000
1901 to 1910	65	$ 1,275,000
1911 to 1921	175	$17,000,000*

*The Rockefeller Foundation, which is included in this last amount, yields nearly five times the amount of all other funds so far established.

It is interesting to note that out of the great number of people of large means in our nation, no less than five hundred, in round numbers, have been sufficiently interested in the advancement of scientific research to make donations for its maintenance; and that of these five hundred individuals, it is a mere score of men that has furnished by far the larger part of the money available for such purposes. Among these we note Smithson, Rockefeller and Carnegie, two of whom are known as among the wealthiest men in our nation.

Though it appears that most donators have provided that the gifts they have made should be used in some particular branch of research, nevertheless by far the largest bequests have been given to research in general; that is, the selection of the particular work to be done has been left to those in trust of the funds. The following table will emphasize these points:

Branch of research specified by donor	Number of funds established	Annual yield
General research work	125	$17,000,000
Medicine	135	$ 4,000,000
Biology and natural history	35	$ 352,000
Physics	34	$ 241,000
Astronomy	22	$ 173,000
Geology	15	$ 137,000
Archeology and anthropology	24	$ 117,000
Botany	14	$ 100,000
Chemistry	65	$ 78,000
Engineering	31	$ 55,000
Zoology	9	$ 49,000
Industrial research	34	$ 49,000
Psychology	8	$ 29,000
Mathematics	3	$ 2,600

It will be noted that medical research heads the list, with 135 established funds and an annual income of $4,000,000. This is doubtless because medical knowledge is generally recognized as of the greatest practical importance to the welfare of mankind. Mathematics brings up the rear. It would probably appear to most of us to be the subject farthest removed from practical interests. Biology, which ranks second, has much to do with the procuring of food, and Psychology, which ranks next to the last, is not yet generally recognized as a subject of practical application.

Copies of the paper here reviewed can no doubt be secured from The National Research Council, 1701 Massachusetts Ave., Washington, D. C.

J. A. Udden

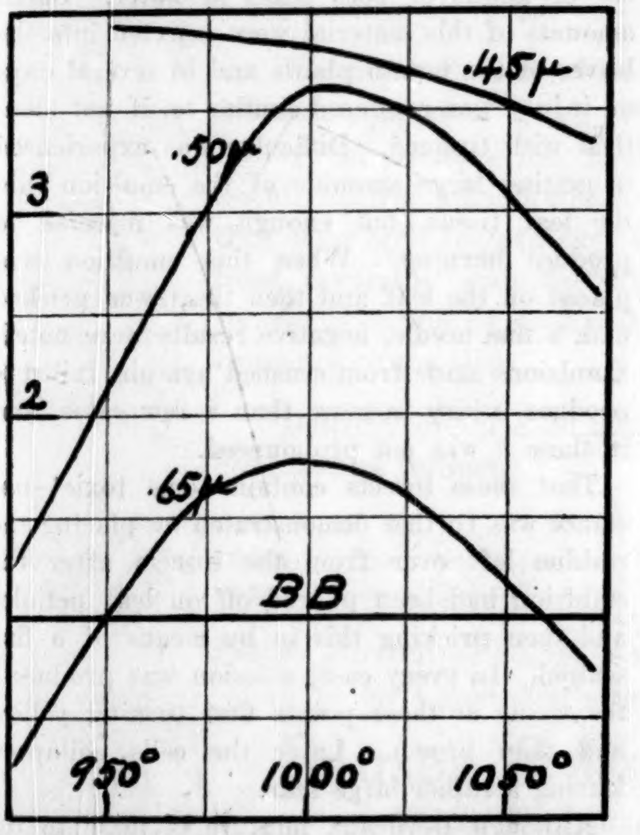
University of Texas

SPECIAL ARTICLES

EMISSION BANDS OF ERBIUM OXIDE: A CONFIRMATION

IN a paper by the late Professor W. G. Mallory [1], published in 1919, a photometric study of the spectrum of glowing erbium oxide was described. When the oxide was heated to 1,000 degrees Centigrade three regions, in which the principal emission bands of this interesting spectrum are situated, were found to be brighter than the corresponding wave-lengths in the spectrum of an ideal black body at the same temperature; the red region slightly brighter and the green and blue several times brighter.

This result has been questioned, although not so far as we are aware in print, on the ground that no radiator can exceed the emission of a black body of the same temperature.



In other words it is held, as a matter of thermodynamics, that the brightest regions in the spectrum of a selective radiator may reach, but never reach beyond, the envelope which encloses the area representing the distribution of radiation from a black body of the same temperature. The explanation offered in Mallory's paper suggests luminescence of the incandescent oxide superimposed upon the ordinary radiation due to temperature.

In the course of studies now in progress, in which an altogether different method is used [2], we find many instances of luminescence superimposed upon the ordinary temperature radiation of incandescent oxides and producing intensities greatly in excess of those of the same regions in the spectrum of the black body. Moreover in the case of erbium oxide we find these excesses in the same regions and at the precise temperature designated by Mallory.

The accompanying figure is from our data for the three regions in question and covers temperatures slightly below 1000°. Intensities are in terms of the brightness of the corresponding radiation from a black body of the same temperature as the oxide and are thus directly comparable with Mallory's results.

While the sample of erbium oxide used by us did not happen to be quite as actively luminescent as in Mallory's experiment the effect is there and is of the same order. His observations are corroborated in every essential respect.

E. L. NICHOLS
H. L. HOWES
PHYSICAL LABORATORY OF CORNELL UNIVERSITY
OCTOBER, 1921

[1] Mallory: *Physical Review* (2) XIV p. 54.

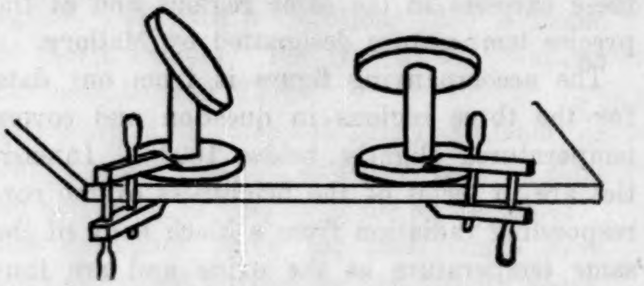
[2] To be described in a forthcoming paper.

LABORATORY DETERMINATIONS OF DIP AND STRIKE

The writer has observed that many geology students are unable to make correct determinations of dip and strike. This weakness seems to be due to the difficulties of presenting the subject in the field, to lack of sufficient laboratory training before entering the field, and especially to lack of suitable apparatus. In the field, the determination of dip and strike appeals to the student as a very minor and uninteresting detail in comparison with the other geological features to which his attention is called. Furthermore, the rock surfaces are usually so irregular that the instructor can not make a very close check of the student's readings. In the laboratory, the tilted drawing boards, table tops, or rock slabs commonly used are not very efficient because they often possess straight edges indicating the line of strike and are usually so insecurely fastened

that checking the readings, again, becomes almost impossible. In an attempt to overcome some of these difficulties the writer constructed the following apparatus which has proved so useful and convenient that it is offered as a suggestion to teachers of geology.

This apparatus consists of two circular pieces of wood about eight inches in diameter, connected by a spindle two inches in diameter and eight inches in length. It is fastened to



the edge of a table by means of wooden clamps. Ordinary iron clamps are not used because they cause a deflection of the compass needle amounting to two or three degrees. The absence of straight edges in the outline of the upper disk necessitates finding the line of strike by locating a position of the clinometer in which no inclination is registered and then drawing a line along the edge of the compass box upon a piece of paper fastened to the top board by thumb tacks. The strike line can be changed to all points of the compass by clamping the apparatus in different positions. The dip is constant for each model but, since several models are necessary for an average class, this is taken care of by making each model with a different dip. Models could easily be made with the dip adjustable but such modifications would mean more expense and more trouble in checking students' readings. Furthermore, it is the direction of dip and not the amount which seems to offer difficulties to the student. It has been found that ten models with dips ranging from three degrees to eighty-eighty degrees answer the purpose.

The models are securely clamped in various positions in the laboratory and their dip and strike determined by the student and checked by the instructor. The models are then turned on their bases, clamped, read, and checked again. The students are then required to make corrections for magnetic declinations, assuming that the models are situated in their own region. The readings are again corrected on the assumption that they were taken in Alaska or Ohio or any other place that the instructor suggests. After the student has gained the ability to make accurate determinations on a series of such models, assuming different geographic locations for the purpose of correcting for magnetic declinations, he is fairly well equipped to use the compass and clinometer in the field.

H. G. Turner
Lehigh University

ARTIFICIAL PRODUCTION OF TIPBURN

Experiments conducted at the Iowa Experiment Station have proved that *Empoasca mali*, the potato leafhopper, is the factor in the production of tipburn or hopperburn of potato. Emulsions were made by crushing a large number of adults of both sexes in water. Small amounts of this material were injected into the leaves of the potato plants and in several days an injury was produced similar to, if not identical with tipburn. Difficulty was experienced in getting large amounts of the emulsion into the leaf tissue, but enough was injected to produce burning. When this emulsion was placed on the leaf and then the tissue pricked with a fine needle, negative results were noted. Emulsions made from crushed nymphs failed to produce injury in more than a few cases, and in these it was not pronounced.

That these insects contain some toxic substance was further demonstrated by placing the residue left over from the insects after the emulsion had been poured off on leaf petioles and then pricking this in by means of a fine scalpel. In every case, a lesion was produced, the tissue at these points first turning yellow and then brown. Later the cells collapsed leaving a rather large scar.

Although Bordeaux mixture is toxic to the nymphs, yet it acts comparatively slowly so that by keeping a leaf sprayed with this compound colonized with live nymphs tipburn was produced. This would appear to show that Bordeaux mixture does not prevent tipburn by its action on the leaf but rather by its action on the insect.

F. A. Fenton and I. L. Ressler
Iowa State College